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Assessment of Spatial and Temporal Trend of Groundwater Salinity in Jaffna Peninsula and Its Link to Paddy Land Abandonment

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Abstract: Salinization is an explicit global threat faced by coastal low lands. The increased seawater ingression into groundwater due to various climatic and anthropogenic factors affects functioning of ecosystems, biodiversity and the sustainability of coastal agriculture. This study was undertaken to investigate the changes in groundwater salinity in Jaffna Peninsula over a 20-year period and its relationship with paddy land abandonment. Permanently abandoned paddy areas were mapped using historical Landsat images, while groundwater salinity changes in 63 agricultural wells for the period 1999 to 2019 were analysed. The trend in salinity, including proximity to the coast, was examined. The results showed that approximately 8178 ha (43% of total paddy land) of paddy lands had been permanently abandoned while the groundwater salinity had increased by 1.6-fold over the last two decades. An increasing salinity trend with decreasing distance from the coast was observed. Presently, nearly 59% of the wells showed salinity levels that were unsuitable for crop irrigation. The results underline the need for urgent and effective management of groundwater resources in order to maintain the sustainability of the existing paddy lands and ensure availability of potable water for consumption along the coastal low land areas of Jaffna Peninsula.

Keywords: groundwater; salinity; coastal salinity; sustainability; Jaffna; coastal agriculture

1. Introduction

Coastal aquifers are the world's most important fresh water resource, especially in arid and semi-arid zones where surface water is scarce [1–3]. The freshwater aquifers in coastal areas plays an important role in human civilisation and socioeconomic developments and have to be protected from contamination threats [4]. South Asia is identified as one of the most vulnerable areas in the world in relation to future coastal freshwater supply [5]. Coastal areas are generally highly populated and, due to the increase of freshwater demand, the groundwater flow patterns are constantly being disrupted and depleted by both overuse and pollution [6]. According to the Intergovernmental Panel on Climate Change (IPCC) fifth assessment report, during the next century, human-induced pressures will play a major role in aquifer recharge and thereby aquifer salinization [7]. Coastal aquifers are directly connected to the seawater and this hydrological connection is important in transporting solutes between land and sea margin [8]. On the other hand, climatic factors, such as increasing temperature, evaporation rate, changes in rainfall, extended drought, rising sea levels and storm surges, are expected to exacerbate intrusion of seawater issues in coastal low lands [7,9].

Coastal agricultural lands are particularly more susceptible to increasing climatic and non-climatic stressors than upland agriculture [6]. This is mainly because they have to cope with the frequent unprecedented changes in coastal ecosystems and anthropogenic disturbances. Saline conditions continue to hinder agriculture, often significantly, by reducing crop yields [10,11]. The situation is more critical in arid and semi-arid climatic regions, where freshwater supplies are minimal relative to the increasing demand for water for agriculture [1,12]. Although each crop responds to salinity differently, it is obvious that if salinity increases above the threshold limit, plants can no longer tolerate this and the yield decreases [13].

The coastal region of Sri Lanka is defined as the area lying within a limit of 300 m landward (from the mean high-water level). It comprises 24% of the total land extent and about 25% of the total population [14]. Some of the productive lands along the coastal belt of the country have been abandoned due to coastal salinity. Approximately 0.112 million ha of land has been affected by coastal salinity (>4 mS cm^{-1}) and more than 50% of the paddy lands in coastal river basins were identified to be abandoned [15]. For example, coastal paddy land abandonment due to saltwater intrusion has been reported in the south coast of the Bentota River basin, where it was found that nearly 2279 ha of paddy lands had been abandoned, resulting in an economic loss of USD 3.6m per year [16].

The adverse impacts of this climate change are higher in Jaffna Peninsula (Figure 1) than in any other part of Sri Lanka [17,18]. Northeast monsoon is the major wet season (80% of the total rainfall) that occurs during October to December. Due to the southwest monsoon, the lesser wet season occurs from April to May. The period between the two monsoon seasons is dry and lasts from June to September. This pattern of heavy rainfall within a short period and little or no rain in the following period has considerable impacts on the recharge of ground water. At the same time, there are no perennial waters due to this uncertainty of rainfall and flat landscape. Hence, groundwater is the only source of fresh water for all domestic, industrial and agricultural requirements in Jaffna Peninsula. Salinity is a major constraint to rice production, which is the most important crop cultivated in Jaffna Peninsula [19–21]. The region has been experiencing progressive seawater intrusion in the coastal aquifers, impacting paddy lands since the 1960s [22,23]. Even though war has been reported to be one of the primary reasons for large-scale agricultural land-use change, the agricultural sector of the Jaffna Peninsula had already been experiencing threats such as seawater intrusion prior to the war [19,20]. The region is mainly underlain by Miocene limestone which is compact and indistinctly bedded and partly crystalline [24]. The porous limestone geology of aquifers is recharged directly by rainfall, which percolates through the fissures and floats as mound-shaped lenses on top of a denser layer of seawater. Significant imbalance has been noted between the draw-off and recharge rate and several studies have reported higher electrical conductivity (EC) values in the groundwater of the Jaffna peninsula [25–28].

In the Jaffna Peninsula, most intensive paddy cultivation occurs on the fertile soil on relatively flat and fertile land along the coastal fringe. About 65% of the population are highly dependent on agriculture through farming of rice as a main staple food crop [29]. However, the region has experienced permanent loss of coastal arable paddy lands due to salinity, leading to a reduction in crop land which has negatively impacted food security and livelihoods of the communities in the coastal region. Thus, an investigation of long-term trends in coastal salinity is crucial in understanding the severity of the increasing risk of coastal salinization in a region like Jaffna Peninsula where groundwater is the major source of freshwater, for both agriculture and human consumption. However, documentation on the long-term effects of salinity on coastal paddy fields remains limited. Most of the coastal studies that have researched and examined water quality parameters, including salinity levels in groundwater systems in the area, have focused on a specific period [30] or short term [27,31–33], the longest period being a one year trend [23,26,34]. This present study is aimed at investigating the spatial and temporal changes in groundwater salinity of Jaffna Peninsula over the last two decades. The specific objectives included an assessment of the present status of coastal groundwater salinization, identification of permanently abandoned paddy fields and examination of the links between groundwater salinity and permanently lost arable paddy lands. This is crucial for the effective management of groundwater and taking appropriate actions for viable and sustainable paddy farming in Jaffna Peninsula.

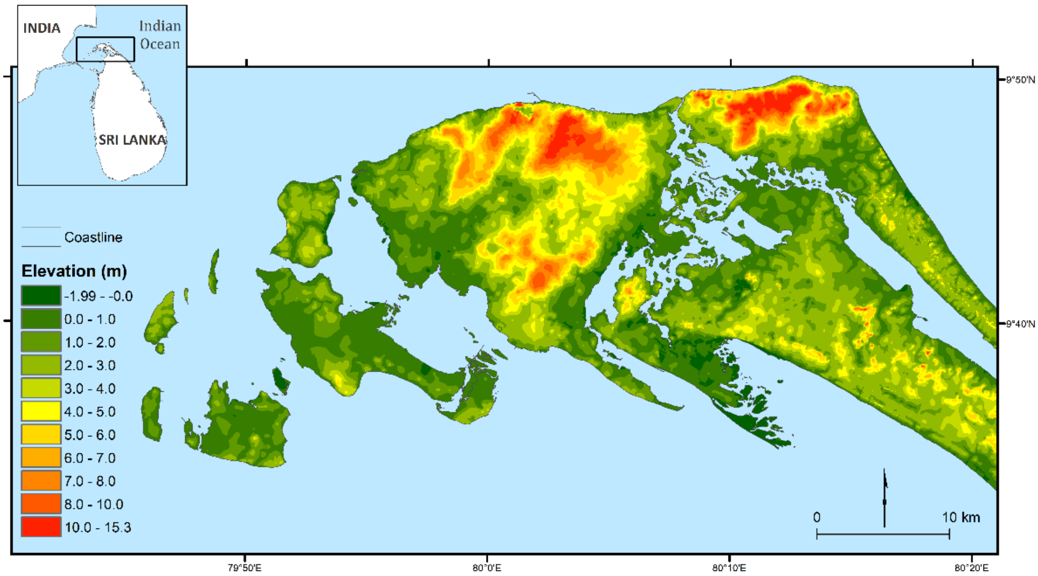


Figure 1. Jaffna Peninsula with increasing elevation shown from green to red.

2. Materials and Methods

Jaffna Peninsula is located in the northern-most part of Sri Lanka (Figure 1). It extends from 9°49′17″ to 9°28′13″ N latitude and 79°38′41″ to 80°34′56″ E longitude. The total land area is 1150 km^2 and it is bounded by the sea on the west, north, and east and by the Jaffna lagoon in the south. It falls in the dry zone climate of Sri Lanka with uniformly high temperature all year around [35]. The topography of Jaffna is almost flat. The highest elevation is 15.3 meters above sea level (masl), with the median being 2.72 m. About 307.4 sq km and 29% of Jaffna falls below sea level. The Miocene limestone of Jaffna Peninsula is well known for its highly productive aquifers [36].

Landsat Thematic Mapper (TM) images of 1988, 2004, 2009 and 2013 and Landsat Operational Land Imager (OLI) images of 2018 were acquired for the assessment of agricultural land-use changes. All the images were obtained from Landsat level 1 tier 1, which are precision and terrain corrected (L1TP). Atmospheric correction was performed to convert digital number values (DN) to reflectance using the Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH) atmospheric correction module in ENVI 5.5. In Jaffna Peninsula, most of the abandoned paddy land has been converted to either barren land, rangeland or wetland. The maximum likelihood classifier was adopted for land use/land cover classification using ENVI 5.5. Post classification spatial filtering was applied to remove the misclassified speckles. Accuracy analysis for the 2018 image was undertaken using ground sample points collected in the field, while Google Earth Pro imagery was used for the 2004, 2009 and 2013 images. Land-use map for the year 1985 from the Survey Department of Sri Lanka was used for accurate analysis of the 1988 image.

The change detection technique was used to analyse changes in paddy land use. This technique is commonly used in remote sensing and is considered as an appropriate approach for comparing two classified images of different time periods [37,38]. In addition, it also provides the nature of the change by providing information on the form to change classes [39–41] and detailed output information from the change matrix [42]. Spatial analyst tools in ArcGIS were used to identify reconverted and permanently abandoned paddy lands. Since some of the paddy lands were temporarily abandoned due to the civil war from 1983 to 2009, with a peak period from 2004 to 2009, multi-year images were used to identify these land abandonments and separate them from those abandoned primarily due to rising water salinity levels. The derived abandoned land from paddy land-use changes of 1988-2004, 2004-2009 and 2009-2013 years were compared/intersected with paddy land use of 2018. The overlapping areas were delineated as reconverted paddy areas and the rest of the areas were identified as permanently abandoned paddy. A pixel had to be paddy land initially and then go to non-paddy land in any subsequent time period and then remain non-paddy in 2018 for it to be classified as permanently abandoned. The accuracy of the derived permanently abandoned paddy land was assessed using 140 independent ground sample points collected from the field in October 2018.

Electrical conductivity is used to measure the salinity of the water samples [43,44]. The groundwater salinity data for the year 1999 was obtained from the Jaffna Peninsula water supply and sanitation feasibility study conducted by the National Water Supply and Drainage Board of Sri Lanka [37]. We conducted a field survey in August 2019 to evaluate the salinity changes that have occurred in the study area. There were 108 wells available for the 1999 well data. Coordinates of these 108 wells were extracted and converted from Sri Lanka Kandawala projection to WGS 84 UTM 44 and input in handheld Global Positioning System (GPS) device (Garmin Montana 610). In addition, the coordinates were fed into GIS for collector application in a tablet to examine the location of the wells. Some of the wells were found to be no longer operational. Some wells were dumped with rubbish and a few could not be located. This left us with 63 wells. Water samples from each of these 63 wells were collected and electrical conductivity (EC) of the water samples were measured in the field using YSI Pro Series Multi-Meter (YSI Inc., Yellow Springs, OH, USA).

In order to increase the confidence level and generalize the present situation of coastal salinity, an additional 93 well water samples were collected and tested for EC. Thus, a total of 156 well data of 2019 was used to investigate the relationship of groundwater salinity with paddy land abandonment alongside other influencing factors, such as proximity to the coast and elevation. The proximity of the wells to the nearest coastline was analysed using spatial analysis techniques. Pearson correlation coefficient was used to test the association between the difference in salinity of the wells and their proximity to the coast. All the spatial analysis and mapping were performed with ArcGIS 10.4 and the statistical analysis and plotting were undertaken in R platform.

3. Results

3.1. Permanently Abandoned Paddy Lands

The accuracy of the classified land use maps for 1988, 2004, 2009, 2013 and 2018 was determined to be 81.6%, 85.09%, 83.46%, 82.9% and 88.2%, respectively. The kappa indices for the respective years were 0.73, 0.79, 0.79, 0.78 and 0.87 respectively. The overall permanently abandoned paddy land distribution is shown in Figure 2. Over the last three decades, nearly 8178 ha of paddy land has been permanently abandoned. This was 43% of the total paddy land in Jaffna Peninsula. Of this, more than 60% was located within 1 km of the coast and in low-lying areas that are below 1 m in elevation. Large portions of paddy lands were abandoned permanently close to the areas around Upparu lagoon, Araly.

3.2. Salinity Changes in Groundwater from 1999 to 2019

Salinity had increased in the majority of the wells. As both year data are positively skewed, a log transformation is applied (Figure 3). A two-tailed Welch's *t*-test was used to account for unequal variance between the two sets of salinity data [45]. The results indicated that the well water salinity of 2019 (M = 3.51 µS cm^{-1}, SD = 0.51) was significantly higher than the well water salinity of 1999 (M = 3.27 µS cm^{-1}, SD = 0.37), t (68.59) = 2.63, p = 0.0104.

These results show that the overall salinity of the sampled wells (N=63) had increased 1.6-fold during the last 20 years. The percentage of change in salinity ranges between –80.2 to 2491.9%. Moreover, 95% of wells had percentage change between –597.7 and 918. Table 1 shows the Food and Agriculture Organization (FAO) classification for saline waters in terms of total salt concentration [46] and Table 2 prescribes the specific water quality guidelines for irrigation [46]. According to FAO guidelines for irrigation (Table 1), the groundwater samples with EC level categorized as "severe" for crops has increased from 30.6 to 41.9% during the last two decades, which likely caused a significant impact on crops grown in the adjacent areas. Table 2 shows that there was a significant decrease (4.9%)

in the number of wells having non-saline water. In 1999, 32.3% of the wells fell within the moderately saline level, while this increased to 41.9% by 2019. Furthermore, in 1999, none of the studied wells had very high salinity or brine; however, in 2019, as salinity levels increased, 1.6% and 6.5% of the wells were categorized as having very high salinity and brine levels respectively.

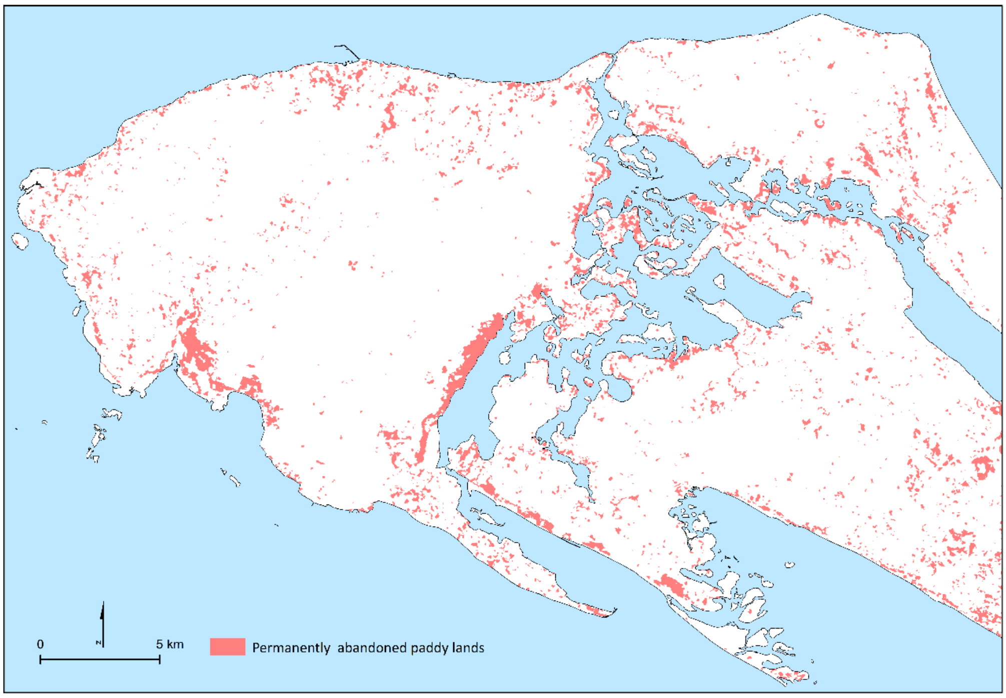


Figure 2. Abandoned paddy lands from 1988 to 2018.

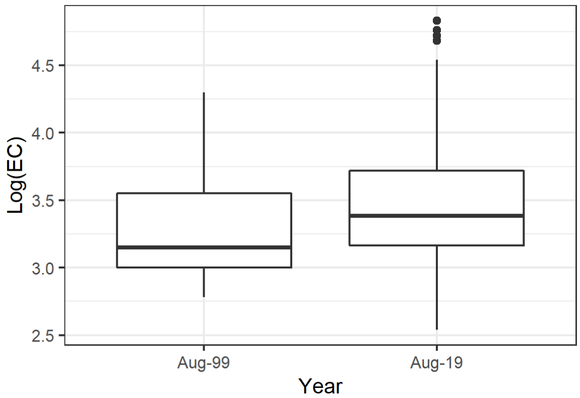


Figure 3. Box plots showing the differences in the electrical conductivity (EC) values of 1999 and 2019.

Table 1. Classification of irrigation water and the percentage of sampled wells.

Level of Restriction on Use	Electrical Conductivity µS cm^{-1}	Percentage (%) in 1999	Percentage (%) in 2019
None	<700	8.1	3.2
Slight to Moderate	700–3000	61.2	54.8
Severe	>3000	30.6	41.9

The spatial distributions of EC (µS cm^{-1}) of the sampled 1999 and 2019 wells overlaid with permanently abandoned paddy lands are presented in Figure 4. This figure clearly shows that the increment of salinity of the wells was comparatively higher in the wells closer to the shoreline than inland and that especially higher EC values were observed in the wells which were located within or very adjacent to abandoned paddy lands. A significant increase in salinity was observed in the western (Araly area) regions where the EC values had increased by more than 20,000 µS cm^{-1} in many wells.

Table 2. Classification of saline waters and the percentage of sampled wells.

Water Class	Electrical Conductivity µS cm^{-1}	Percentage (%) in 1999	Percentage (%) in 2019
Non-saline	<700	8.1	3.2
Slightly saline	700–2000	53.2	37.1
Moderately saline	2000–10,000	32.3	41.9
Highly saline	10,000–25,000	6.5	9.7
Very highly saline	25,000–45,000	0	1.6
Brine	>45,000	0	6.5

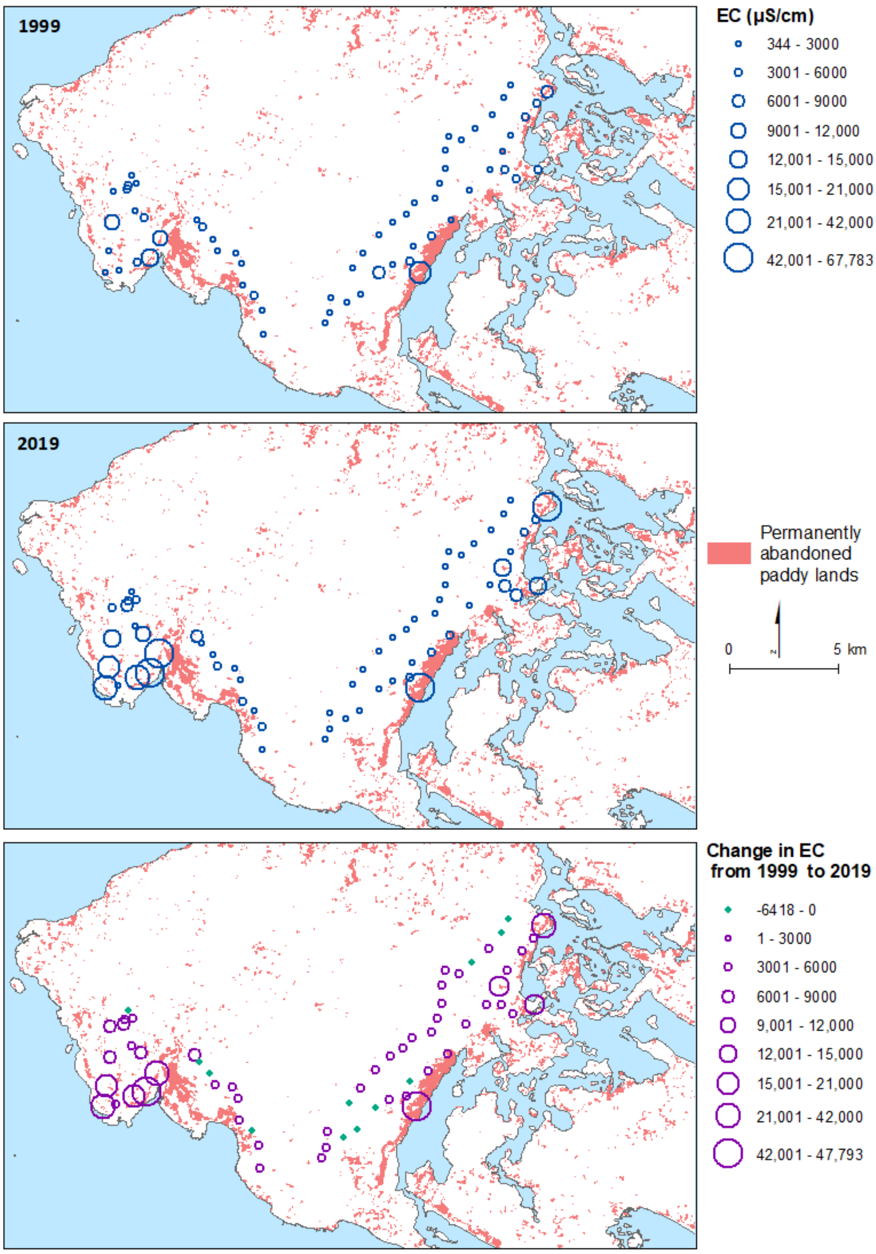


Figure 4. Distribution of groundwater salinity levels in selected wells within the permanently abandoned paddy for the years 1999 and 2019 in Jaffna Peninsula and the observed changes. Graduated symbols in blue colour represent the ranges of increasing EC values. The graduated symbols in purple colour shows the magnitude difference of EC values between 1999 and 2019.

3.3. Present Status of Coastal Salinity

Figure 5 illustrates the current status of salinity along the coastal fringe of Jaffna Peninsula based on well data collected in 2019. This figure also shows a distinct pattern of higher salinity prevailing in the groundwater over the permanently abandoned paddy lands.

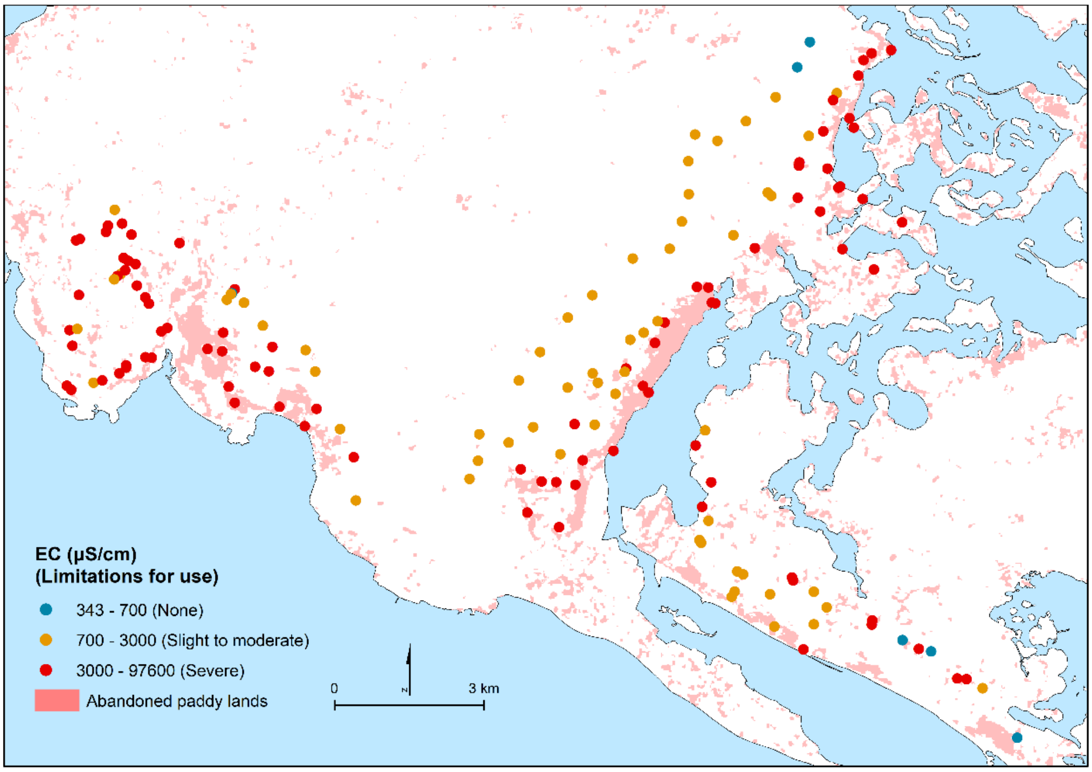
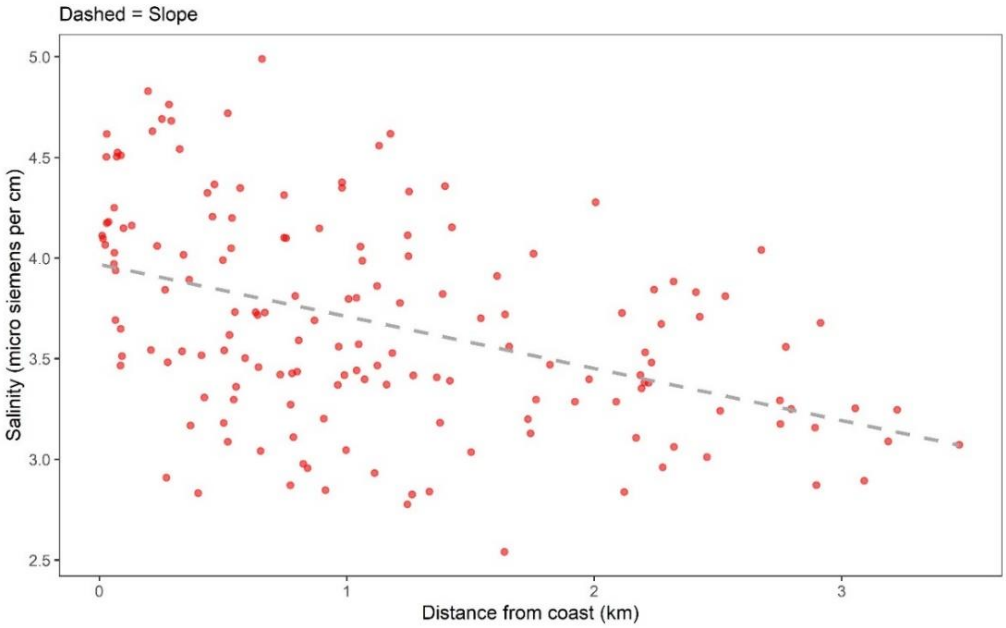
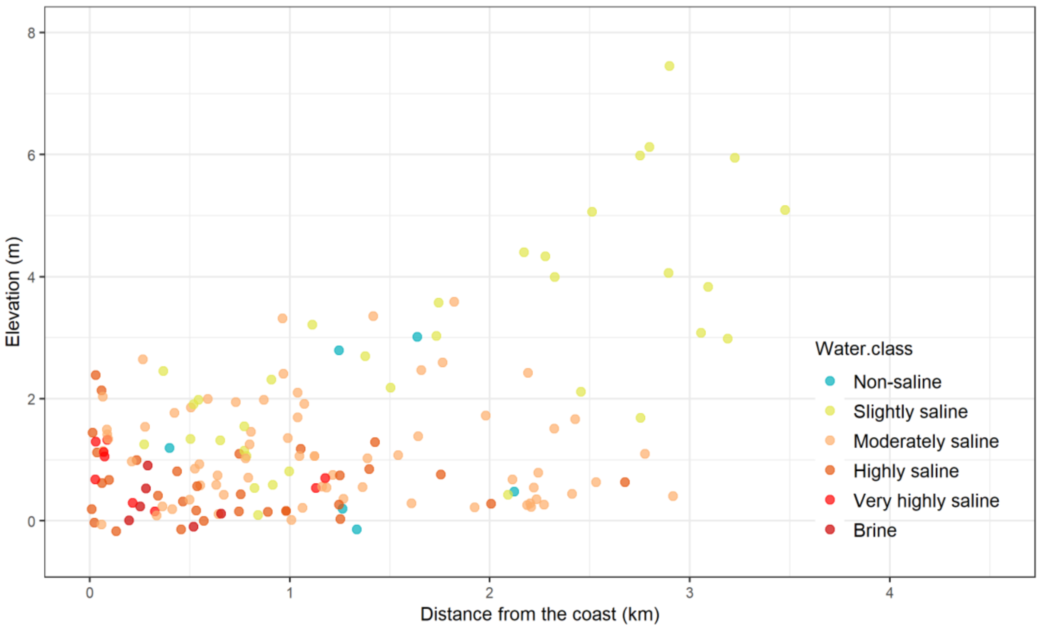


Figure 5. Distribution of 156 wells plotted with permanently abandoned paddy lands in the Jaffna Peninsula and EC levels for 2019 showing their limitations for use for irrigation.

The distribution of EC values for the 156 sampled wells and their relationship with elevation and distance from the coast are shown in Figure 5. Overall, there was a negative correlation between EC and distance from coast ($r\ (156) = 0.35$, $p < 0.01$) (Figure 6a). In terms of salinity classes, 44% of the groundwater was categorised as "moderately saline" and 20.3 fell within the salinity class "highly saline". Moreover approximately 6 and 4% of groundwater was classified as "very high saline" and "brine" respectively. The EC of the wells increases with decreasing proximity to the coast. Out of 156 wells, 59% showed salinity levels that were classified as "severe" as per the FAO guidelines on irrigation water quality. Of the wells that exceeded permissible salinity levels (severe), 86% were located less than 2 km from the coast and 62% located within 1 m above msl. In addition, 67% of wells were located less than 1 masl, while 78% of the wells were below 2 masl and within 2 km distance from the coast (Figure 6b).



(a)



(b)

Figure 6. (**a**) Linear regression graph of salinity trend between EC of wells and their distance from the coast. (**b**) The scatterplot depicting elevation and distance of the 156 wells that were studied in 2019. The EC values (µS cm^{-1}) for the various wells is shown in different colour variations.

4. Discussion

The results of this study show that Jaffna Peninsula is experiencing a serious salinization issue. The salinity of the 63 sampled wells had increased significantly from 1999 to 2019, with the average increase 1.6-fold over the past two decades. As per FAO classification of saline water [46], the wells fell within the moderate to high salinity hazard zone and have shown an increase in the number of wells in these categories from 38.8% to 51.6% during last two decades. Of the wells, 6.5% showed salinity levels as “brine” (with EC values more than 45,000 µS cm^{-1} unit), which is nearly the salinity of seawater. The current status of the salinity of the 156 sampled wells also shows that there was an inverse correlation between salinity and distance to the coast, where higher salinity levels were found in wells close to the coast and this tended to decrease with the distance from the coast. The highly saline EC level (>10,000 µS cm^{-1}) extended over 2.7 km inland. In addition, 59% of groundwater exceeded the threshold value (3000 µS cm^{-1}) for irrigation and majority of them (>50%) located in lowlands (<2 masl) close proximity to coast. This finding is consistent with that of Sood et al. [47] who also found higher salinity levels near coastal regions in Jaffna Peninsula compared to inland during both pre- and post-monsoon periods. It should be noted that the overall water sampling was conducted in the wells which are located within 3.5 km proximity to the coast, hence the statistical considerations are conditioned/bounded by the sample selection. The most intensive salinity level in Jaffna Peninsula is reported in August during the dry season, which is characterized by high temperature and high evaporation rates [27]. However, climate change induced droughts could further exacerbate this situation.

Several groundwater studies have indicated that even moderately saline groundwater appears to be a major contributor of secondary soil salinization and subsequent degradation of irrigated lands. Eventually, the groundwater salinization will make soil unsuitable for the development and production of many crops [48]. Groundwater is crucial for the livelihoods and food security of the rural farming communities in Jaffna Peninsula. Most of the population rely on agriculture for their livelihood. However, the presence of high salt concentration in water and soil are not suitable for the cultivation of many common crops, thereby threatening the crop growth and sustainability of the agricultural lifestyle of the people of Jaffna Peninsula. The most affected crop is paddy rice, which is the main crop that is commonly cultivated along the coastal low lands of Jaffna Peninsula. Over the last 30 years (from 1988 to 2018), nearly 8178 ha of the paddy land has been permanently abandoned. This represents 43% of the total paddy land of Jaffna Peninsula. The majority of these abandoned paddy lands are located very adjacent to the coastal fringe, with more than 60% of them located within 1 km from the coastal shoreline and in areas that are below 1 m in elevation. The significant increment of groundwater salinity in the wells located within or very adjacent to permanently abandoned paddy lands shows that increasing coastal salinity could be the primary reason for the loss of arable paddy lands in these regions. Specifically, the western region of the Jaffna Peninsula (Valuki aru region), where the abandoned paddy lands are more concentrated showed greater increment in salinity. Rajasooriyar, Mathavan, Dharmagunawardhane and Nandakumar [23] also reported an increment of 55% of salinity in the western region (Valuki Aru) from 1982 to 1997, although this is much lower than the EC values we have measured over the 20-year period. These results are in line with previous studies, which have reported that hundreds of wells have become brackish and a considerable number of arable lands have been abandoned [21,49,50].

The salinity issue has been perceived as a threat in Jaffna Peninsula since the 1950s [22]. The coastal groundwater salinization in Jaffna Peninsula can be due to a combination of natural and anthropogenic factors. The spatial dynamics of the salinity in underground water aquifers are often influenced by the tidal surges, such high tides, which push the saline water-freshwater head further into the groundwater. Jaffna Peninsula, owing to its geographical location and geomorphological condition, is one of the most vulnerable regions in Sri Lanka to coastal hazards. The coastline extends for 160 km and the landscape is almost flat, with the median elevation being only 2.7 masl. Also, no region of Jaffna Peninsula is more than 10 km from the coast. Several studies have reported seawater intrusion was identified to be the major reason for the elevated EC levels in the well water [49,51]. Wells which were once used to supply potable water to the people of Jaffna Peninsula have been abandoned due to the increased salinity, as reported by Nandakumar [50]. In addition, although recharge is governed by rainfall, less rainfall and higher evaporation rates leaves only 30-32% of the rainfall for groundwater recharge in Jaffna Peninsula [52], which is insufficient to meet the demand in dry seasons.

A recent study on groundwater quality and availability in Jaffna Peninsula identified that the indiscriminate extraction of groundwater owing to post-war development projects, agriculture expansion and resettlements could be the major reason for the water quality deterioration [28]. The intensive agricultural practices adopted in the last three decades has also worsened the salinity issue in groundwater [35]. The rainwater percolates into the karstic limestone and floats as lens on denser seawater. This thickness of the freshwater lens is limited by the flat topography of Jaffna Peninsula, lower in the coastal areas and relatively thicker in the central region. During the dry season, as the groundwater depletes, the thickness of the lens declines and becomes more sensitive to abstraction. Over-extraction of groundwater causes these freshwater heads in underground aquifers to further lower and the fresh-saline water interface to rise, resulting in seawater intrusion. A number of studies have reported recharge rates are insufficient to balance the draw-off in the shallow karstic aquifers of Jaffna Peninsula [23,53,54]. In some places the abstraction has exceeded even 100% of the annual recharge owing to over extraction where groundwater table drop of 85.1 cm was reported during the dry season [53].

The wells located close to the coastal shoreline have shown greater increment than those in hinterland. The current status of the salinity of the 156 sampled wells also shows that there was an inverse correlation between salinity and distance to the coast, where higher salinity levels were found in wells close to the coast and this tended to decrease with the distance from the coast. This trend of increasing salinization along the coast depicting an inverse relationship with distance from the coastal shoreline indicates the influence of seawater [55]. However, a more detailed study is required to ascertain the dynamics of the groundwater–seawater interaction.

These findings might further indicate that Jaffna's coastal groundwater system is severely threatened by relatively high salinity levels and has significantly impacted the paddy cultivation in the region. Climate change and accelerating population growth are expected to further exacerbate this pressure on coastal aquifers. With suitable land for paddy cultivation constantly decreasing as salinity increases, and with a rising population to feed, the pressures on the remaining productive paddy fields and suitable irrigation wells will be immense. With limited rainfall, over-extraction may be the only recourse to maintain sustainability of paddy farming in Jaffna Peninsula. This is likely to exacerbate the already dire problem.

Therefore, well-designed policies and integrated, holistic approaches towards prevention and remediation of coastal salinization of groundwater are needed. Such strategies should consider continuous monitoring and assessment of salinity levels in groundwater systems in Jaffna Peninsula, together with improved rice varieties that can survive with limited water or those that are salt tolerant [56]. Installation of rainwater harvesting and artificial recharge systems are apt strategies to recharge and improve the quantity and quality of the aquifers of Jaffna Peninsula where high intensity rainfall is received in short duration. This will also help to reduce overexploitation in the dry seasons. Refurbishing the existing protective dikes and barrages as water tight and equipped with control gates in order to release the excess stormwater can help to mitigate the impacts of coastal flooding [57]. Stringent regulations on issuing permits for construction of new wells near shore areas would reduce the seawater intrusion. Coastal vegetation has been shown to be a low-cost bio-shield in dissipating energy of storm surges and waves. Satyanarayana, Van der Stocken, Rans, Kodikara, Ronsmans, Jayatissa, Husain, Koedam and Dahdouh-Guebas [18] reported in their study on coastal vulnerability assessment of Sri Lanka that the places devoid of natural coastal protections like mangroves, sand dunes and *Casuarina* were identified to be more vulnerable to tsunami waves than the areas protected with bio-shield structures. Jaffna Peninsula was found to have 60% vulnerability to water related impacts, including the area at 2 km from the coast. The study also highlighted the importance of giving priority to coastal conservation to Jaffna Peninsula.

The findings of this study need to be seen in light of some limitations. For instance, apart from the salinity problem, there could be other socioeconomic and environmental reasons for paddy land abandonment in Jaffna Peninsula. Importantly, overexploitation of paddy lands and migration of farmers to Colombo or to other countries are such possibilities. In addition, while the majority of the lands abandoned due to the civil strife were removed from the permanently abandoned category, it is possible that some may have remained. However, the pattern of a majority of the abandoned paddy lands located in close proximity to the coastal shoreline and the increased groundwater salinity levels within the abandoned paddy regions shows that the primary reason of abandonment is most probably salinization.

5. Conclusions

In the present study we analyzed the spatiotemporal changes in salinity levels in groundwater over a period of 20 years and its link to the loss of paddy lands in Jaffna Peninsula. The results indicate that Jaffna Peninsula is experiencing a serious salinity issue. The coastal ground water salinity has increased remarkably 1.6-fold during the last two decades. Together with this, nearly 8178 ha of paddy lands close to the coastal shoreline has been permanently abandoned over the last 30 years. Jaffna Peninsula is currently undergoing rapid post-war developments with considerable changes in coastal low land use. Increasing human settlements along the coastal belt can further affect the aquifers. The problem is also likely to get worse with climate change where rising sea levels will lead to faster rates of salinity increases in the water tables and so potentially greater rates of land loss. The findings of this study, considering that it is one of the first long-term investigations on the changes in water salinity in Jaffna Peninsula, form an important basis for groundwater quality monitoring and development of appropriate strategies towards sustainability of existing coastal paddy lands. With a rising population and decreasing suitable paddy lands, food security in Jaffna Peninsula could be a major challenge in years to come.

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